Review article
UDC: 577.161:796
doi:10.5633/amm.2013.0412

FATSOLUBLE VITAMINS AND SPORT

Novica Bojanić[1], Jelena Radović[2], Nina Jančić[2], Nataša Đinđić[2]

Vitamins are the cell biocatalysts, indispensable factors in performing the basic body functions. Fat-soluble vitamins are not involved in processes related to musscle contractions and energy expenditure, but they can affect physical performance indirectly because they are important for immune function (vitamin A, vitamin D, vitamin E), antioxidant function (vitamin A, vitamin E) or bone methabolism (vitamin D, vitamin K). Currently there are no clear recommendations for increase of fat-solubile vitamins intake in athletes, as well as evidence that athletic performance may be improved due to fat-solubile vitamins supplementation. In a small number of studies, it was shown that an antioxidant effect of beta carotene and vitamin E can prevent muscle damage and facilitate recovery after exercise. Also, athletes who perform the exercises in the halls should be informed about the necessity of sun exposure, as vitamin D is synthesised in the skin.

Most athletes are not familiar with their needs for vitamins and trace elements, and take these compounds as supplements without consulting a nutritionist. It is important to emphasize that liposulubile vitamins are deposited in the body and can cause hypervitaminosis and toxic effects if taken in excess.

It is indisputable that the lack of any fat-soluble vitamin cause problems in normal physiological processes, but supplementation is generally not required in athletes who have a well-balanced diet. *Acta Medica Medianae 2013;52(4):63-68.*

Key words: *fat-soluble vitamins, sport, vitamins supplements, hypervitaminosis*

University of Kragujevac, Faculty of Medical Sciences, Kragujevac, Serbia[1]
University of Niš, Faculty of Medicine, Niš, Serbia[2]

Contact: Jelena Radović
University of Niš, Faculty of Medicine
Bulevar Dr Zorana Đinđića 81, 18000 Niš, Serbia
E-mail: jelenaradovic982@gmail.com

Introduction

Vitamins are the cell biocatalysts, indispensable factors in performing the basic functions of each cell. Group of fat-soluble vitamins comprise vitamin A, D, E and K. They are absorbed with fats from food and later get into the liver where most of them are deposited. The excessive accumulation of these vitamins may occur due to their excessive intake and cause toxic effects. Vitamin deficiencies, on the other hand, may aggravate many physiological processes. Vitamin D is the only fat soluble vitamin produced in the human body by exposure of the skin to the sunlight (ultraviolet B rays).

Athletes' needs for vitamins may be greater than in non-athletes. Strenous physical activity increases: energy and oxygen consumption, production of free radicals and activity of free radical scavengers. Lipid peroxidation can be reduced by supplementation with antioxidants. Vitamin E and beta carotene are potent antioxidant agents. Besides, athletes have increased losses of many micronutrients trough sweat and urine compared to non- athletes.

Vitamin needs depend on the sport type, training load and duration, and environmental conditions. Many athletes usually take a lot of vitamin supplements, although they are often not familiar with recommendations for their use (1-4). Most commonly taken supplements are those of vitamin C, vitamin E, and multivitamin complexes, and lately an omega-3 fatty acids supplements. The athletes are taking vitamin supplements primarily to prevent their deficiencies, under the excuse of preventing cold or exhaustion and for recovery from exercise. Only a small number of athletes consult with a professional dietitian before using supplements (5,6).

Dietary reference intake standards (Dietary Reference Intake - DRI) are based on evaluation of the estimated average requirements (Estimated average requirements - EAR), recommended daily dietary needs (Recommended dietary allowances - RDAs), adequate intake and tolerable upper limit of allowed entries (7). Sufficient and well-balanced diet meets daily requirements for all vitamins (Table 1) and provides a standard reference intake (Table 2). Since liposulubile vitamins are found in fat rich food, athletes should not avoid this type of food completely. All fat-soluble vitamins can effectively be deposited

Table 1. The food that has distinct liposoluble vitamins (1,2,4)

Vitamin A	Retinol: organ meats, butter, cheese, egg yolk, fish oil, liver, milk and milk products; Beta-carotene: fruits and bright and dark green vegetables
Vitamin D	Fish liver oil, egg yolk, canned fish, organ meats, fortified milk and margarine, butter, green leafy vegetables
Vitamin E	Vegetable oils, oils from cereal and margarine (corn, soybeans, wheat, olives), small amounts of enriched grains and eggs, pumpkin seeds, walnuts, peanuts, almonds, hazelnuts, cereals
Vitamin K	Various types of vegetable oils and dark green leafy vegetables (cabbage, spinach, nettle); liver, milk

Table 2. The referent dietary intake (DRI) and daily recommendations for adult athletes (1,2)

Vitamin	DRI		The recommendations
	male	female	
Vitamin A	900 μg	700 μg	700 - 900 μg
Vitamin D	5 μg	5 μg	5 - 15 μg
Vitamin E	15 mg	15 mg	15 mg
Vitamin K	120 μg	90 μg	700 - 900 μg

in the body and supplements are rarely needed (1). Nausea, vomiting, diarrhea and skin changes are some of the symptoms and signs common with any acute or chronic vitamin overdose.

The aim of this paper is to present the current knowledge and the recommendations of athlete needs for fat-soluble vitamins, as well as the rational basis for their use. The athletes on fat-soluble vitamins supplementation should be aware of their intake needs, especially because hypervitaminosis may be developed due to excessive intake.

Vitamin A

Vitamin A (axeroftol, retinol) comprises retinoids, retinol and its metabolites, as well as provitamin A carotenoids. About 40 carotenoids are consumed regularly in human diet, but only a few of them have provitamin A activity. The most common carotenoids are alpha-carotene, βετα-carotene and α-cryptoxanthin (1,8).

Vitamin A has a well-known role as a precursor in the synthesis of visual pigment, rhodopsin. It is required for cell growth and differentiation, especially of epithelial cells and bone. It has essential actions in organ development during embryonic and fetal growth. Vitamin A plays a role in normal red blood cells function, immune system and reproductive organs. It is also an antioxidant and anti-cancer agent (2,4,7,9).

Retinol can be taken from animal foods, while the carotenoids have a plant origin (Table 1). In 2001 the International Olympic Committee introduced the retinol equivalent unit (RE), which expresses the vitamin A activity of carotenoids (9). One RE is equal to 1 mcg retinol, 12 mg beta-carotene, 24 mg alpha-carotene or 24 mcg beta-cryptoxanthin. Vitamin A DRI ranges from 700 RE for women and 900 RE for men. The maximum upper limit of the side effects risk is 3000 RE (1,4).

Although vitamin A is a weak antioxidant, it is probably needed for the intensive metabolism during exercise. Well-nourished athletes do not show signs of this vitamin deficiency. Nevertheless, some athletes take excessive amounts of vitamin A, which can be harmful and toxic. It has been shown that supplementation does not have positive effects on physical activity. Also, it is easy to exceed the upper intake limit by taking multiple daily doses of supplements, which contain 100% RDA, together with a diet rich in animal products, about which athletes should be warned (1,10).

Beta carotenes are precursors of vitamin A that do not exhibit the same toxic effects at high doses. They are powerful antioxidants and are assumed to reduce muscle pain and facilitate recovery after exercise, although no study to date has shown a direct connection between these observations. It is believed that carotenoids reduce the risk of macular degeneration of the retina and cataract, cardiovascular disease and some cancers. The only clear explanation of these effects is through the activity of vitamin A (1,4,8).

According to some studies (2,4), athletes' needs for this vitamin are considerably above the needs of non-athletes, and they increase with higher physical activity and low temperatures. However, there are no specific recommendations for athletes regarding the expanded use of vitamin A or carotenoids.

The consequences of chronic vitamin A toxicity are erythema, dry skin and mucous membranes, conjunctivitis, blurred vision and headaches. There may be pain and tenderness in the muscles and bones, especially the long bones of the limbs, and pain after exercise. Some studies (11,12) indicate increased bone resorption caused by high levels of vitamin A, and intracranial hypertension, hepatomegaly, arthritis, intrauterine growth restriction etc., while carotenoids are relatively non-toxic compounds (4,9,13).

Vitamin D

Vitamin D (calciferol) is a liposulubile vitamin that is synthesized in the skin from 7-dehydrocholesterol with the action of ultraviolet B rays of the sun. Cholecalciferol passes through the two chemical conversions in the liver and kidneys, before it becomes an active hormonal form (1α,25-dihydroxyvitamin D3) (14).

The best known role of vitamin D is in maintaining the homeostasis of calcium and phosphorus through its effects on intestine, kidney and bone, in conjunction with parathyroid hormone. Vitamin D also affects the function of other organs and organ systems (immune system, heart, CNS and other). Biological function of vitamin D is defined as an antiproliferative and pro-differential (14,15).

Vitamin D can be taken from food (Table 1), but these amounts are not sufficient to prevent deficiency if its synthesis in the skin is disabled due to reduced sun exposure. Vitamin D interacts with iron, so iron deficiency can cause a reduction in intestinal absorption of vitamin D (16).

The adult DRI is 5 mg or 200 International Units (IU) (1 mg calcipherol is 40 IU of vitamin D). The upper tolerance limit is 50 mg. Intake over this tolerance limit causes serious toxic effects, and this must be followed when taking vitamin D supplements (1,4).

There is no evidence that increased intake of vitamin D improves athletic performance, there is not even theoretical basis for such thinking. Positive effect may have its indirect role in the proper bone mineralization and increased bone resistance to injury (1,4).

Vitamin D deficiency can occur in athletes who train in the halls where they are less exposed to the sun (gymnasts). Lack of Vitamin D leads to slow growth and decreased bone density, which increases the risk of stress fracture incidence (17,18). In Lovell's study (19) a deficiency of vitamin D was recorded in one third of young female gymnasts.

Acute toxicity of vitamin D is the result of hypercalcemia (weakness, headache, nausea, bone pain). In addition to these signs constipation, polyuria, hyperlipidemia, calcinosis, hypertension and arrhythmia may develop in chronic toxicity (13).

Vitamin E

Vitamin E (tocopherol) is composed of several chemical compounds with similar activity, however only alpha-tocopherol is considered to be biologically active in humans. Vitamin E plays an important role as an antioxidant. It "collects" peroxide radicals, becomes oxidized, thus protecting unsaturated lipids in cells and plasma. Oxidized vitamin E can be converted in reduced state by other antioxidants (1,8). It is shown to have anti-inflammatory and antiatherogenic effect, as well as anticoagulant activity, so that extensive supplementation causes hemorrhage (4,20).

Vitamin E activity is measured by activity of alpha-tocopherol equivalents, while beta-tocopherol has lower activity. The DRI for adult is 15 mg per day, which is easily provided by sufficient intake of vegetables (Table 1). Doses of supplements are expressed in IU. One milligram of alpha-tocopherol is about 1.5 IU of vitamin E. The upper limit of vitamin E is 1000 mg per day (8). Vitamin E deficiency is rare, and can be manifested as peripheral neuropathy, muscle weakness, ataxia and retina damage. It is relatively non-toxic substance when consumed from foods (8,13).

There are a few studies related to vitamin E supplementation in athletes. However, there is no recorded benefit from increased intake of this vitamin so far in relation to athletic performance, strength, endurance and recovery after exercise (20,21). Nevertheless, athletes often use vitamin E supplements to prevent muscle damage and weakness (22). There is experimental evidence that vitamin E deficiency leads to skeletal muscle dystrophy, also muscular atrophy was less intensive after vitamin E supplementation. Supplementation is recommended after immobilization and remobilization (23). Vitamin E increases the activity of oxidative enzymes in muscle cells mitochondria, which can increase oxygen utilization during intense muscular work. It is shown that oxygen utilization increases during exercise at high altitude with extra vitamin E intake (24). As an antioxidant, it can reduce oxidative muscle damage after strenuous exercise, but there are no clear studies results on this issue. All the abovementioned results justify its use in terms of maintaining the optimal muscle function (2,3,21, 25).

There are currently no specific recommendations for vitamin E intake for athletes, except in cases when strength is very important, and who may need to take more than the recommended dose (4). Several studies have shown that vitamin E can help prevent lipid peroxidation after exercise and recommend supplements of 100 and 200 mg per day (25). According to the study of Ji et al. (26), it is important to achieve the balance between pro-oxidants and antioxidants. Antioxidants provide to physically active individuals more protection, as well as to older people who have reduced amount of anti oxidative enzymes (3). However, comprehensive studies are still needed in order to determine the exact effect of vitamin E and its recommendations for athletes.

In addition to non-specific symptoms of toxicity, acute overdose of vitamin E can cause bleeding, hematomas, muscle weakness and creatinuria. With the inhibition of vitamin K dependent carboxylase vitamin E reduces the synthesis of vitamin K-dependent coagulation factors, and thus increase prothrombin time and partial thromboplastin time. Also, vitamin E reduces platelet thromboxane production, reducing platelet aggregation (13,27). Excessive bleeding was noted in combination with aspirin and this vitamin (28). In a meta-analysis of Miller and Bjelakovic (29,30) it has been shown that supplementation with high doses of vitamin E increase the overall mortality. Bjelakovic et al. (30) in their study of antioxidant supplements use concluded that the use of beta carotene and vitamins A and E may increase mortality.

Vitamin K

Vitamin K consists of three biologically active forms: vitamin K1 (phylloquinone) the major dietary form; vitamin K2 (menaquinone) synthesized by the intestinal flora and vitamin K3 (menadione), a synthetic form which body can metabolize to yield active phylloquinone, used as a coagulant (4). Vitamin K is found in numerous vegetables, fruits and meat and it is produced by the gastrointestinal tract bacteria. It is also recycled by body to conserve its stores.

For that reason, the overall dietary needs cannot be accurately determined (Table 1). People taking antibiotics which destroy the intestinal flora are at risk of vitamin K deficiency (1,9) as well as patients on anticoagulation therapy or with fats malabsorption.

Signs of vitamin K deficiency include: easy bruising and hemorrhages, and age-associated conditions and diseases: such as loss of bone (osteopenia) and arterial calcification associated with cardiovascular disease (31).

Vitamin K seems to be a relatively nontoxic compound. However, high intake of the synthetic forms of vitamin K can cause hemolysis of red blood cells, jaundice and brain damage. A high level of vitamin K inhibits the effects of oral anticoagulants (13). There are 16 known vitamin K-dependent (VKD) proteins. Five VKD proteins are involved in coagulation and next five VKD proteins are included in bone metabolism. In fact, vitamin K acts synergistically with vitamin D and positively influence bone mineralization and calcium balance in the blood, and is important for the synthesis of proteins involved in bone formation (gamma-carboxy glutamic proteins family). Vitamin K enhances bone mineral density in osteoporosis and reduces the risk of fractures (1,32). Boot et al. (33) found that increased vitamin K doses reduce the risk of hip fracture.

The influence of vitamin K on athletic performance has been insufficiently studied. It is assumed that an adequate intake is essential in contact sports to prevent the occurrence of bruising and bleeding (1,4). Due to its role in bone metabolism it is essential for skeletal growth in young athletes. Craciun et al. (34) showed in their study the improvement of bone metabolism in female athletes after vitamin K supplementation.

Vitamin K deficiency in athletes has not been documented (35).

There is no clear basis for ergogenic benefits from supplementation of this vitamin, and, therefore, there is no increase in recommendation for athletes. A possible impact of vitamin K in healing bone fractures, due to its role in osteocalcin synthesis, is yet to be studied.

Conclusion

Fat-soluble vitamins participate in a number of different functions in the body. A well balanced diet covers the needs for these vitamins in athletes and the deficits can rarely be seen. Supplementation is generally not necessary and most studies did not show any additional beneficial effect on athletic performance using fat-soluble vitamin supplements. Supplementation is necessary for people who for various reasons do not take enough nutrients or who are on restrictive diets. Because fat soluble vitamins are stored in the body there is a greater risk of overdose, compared to water soluble vitamins. Therefore, the attention must be paid to their upper intake limits. Athletes should not take fat-soluble vitamin supplements without prior consultation with a sports nutritionist.

References

1. Benardot D. Vitamini i minerali. U: Benardot D. Napredna sportska ishrana. Beograd: Data Status; 2010: 36-54. Serbian.
2. Đurašković R, Popović-Ilić T. Poglavlje 16. U: Đurašković R. Sportska medicina. 3-će dopunjeno izdanje. Niš: Centar za izdavačku delatnost Fakulteta sporta i fizičkog vaspitanja, Univerziteta u Nišu; 2009:541-6. Serbian.
3. Melvin H Williams. Dietary supplements and sports performance: introduction and vitamins. J Int Soc Sports Nutr 2004;1(2):1–6. [CrossRef] [PubMed]
4. Young-Nam K, Driskell JA. Vitamins. In: Driskell JA, Wolinsky I, editors. Nutritional concerns in recreation, exercise and sport. New York (NY): CRC Press; 2009: 91-114.
5. Knez WL, Peake JM. The prevalence of vitamin supplementation in ultraendurance triathletes. Int J Sport Nutr Exerc Metab 2010;20(6):507-14. [PubMed]
6. Heikkinen A, Alaranta A, Helenius I, Vasankari T. Dietary supplementation habits and perceptions of supplement use among elite Finnish athletes. Int J Sport Nutr Exerc Metab 2011;21(4):271-9. [PubMed]
7. Nagao A. Absorption and function of dietary carotenoids. Forum Nutr 2009;61:55-63. [PubMed]
8. A Report of the Food and Nutrition Board, Institute of Medicine. Chapter 6: Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Caroten oids. Washington, DC: National Academy Press; 2000. [CrossRef]
9. A Report of the Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium and Zinc. Washington, DC: National Academy Press; 2001.
10. West CE, Eilander A, van Lieshout M. Consequences of revised estimates of carotenoid bioefficacy for the dietary control of vitamin A deficiency in developing countries. J Nutr 2002;132:2920S–6S. [PubMed]
11. Dietary Supplement Fact Sheet: Vitamin A and Carotenoids. National Institutes of Health - Office of Dietary Supplements [Internet]. 2007 Jul. Available from http://ods.od.nih.gov/factsheets/vitamina.asp.
12. Pazirandeh S, Burns DL. Overview of vitamin A. UpToDate [Internet]. 2007 Jul. Available from: www.uptodate.com. 2007.
13. Rosenbloom M. Vitamin Toxicity Clinical Presen tation. Medscape: Drugs, Disease & Procedures [Internet]. New York (NY): WebMD LCC; [updated Feb 2011; cited Jan 2012]. Avalable from: http://emedicine.medscape.com/article/819426-clinical
14. Jones G, Strugnell SA, DeLuca HF. Current under standing of the molecular actions of vitamin D. Physiol Rev 1998;78:1193–231. [PubMed]
15. A Report of the Food and Nutrition Board, Institute of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Washington, DC: National Academy Press; 1997.
16. Keith RE. Ascorbic acid. In: Driskell JA, Wolinsky I, editors. Chapter 2: Sports Nutrition: Vitamins and Trace Elements. Washington, DC: National Academy Press; 2006.
17. Barr SL, Prior JC, Vigna YM. Restrained eating and ovulatory disturbances: Possible implications for bone health. Am J Clin Nutr 1994;59:92-7. [PubMed]
18. Heaney RP. Effect of calcium on skeletal develop ment, bone loss, and risk of fractures. Am J Medicine 1991;91(Suppl 5B):23-8. [CrossRef] [PubMed]
19. Lovell G. Vitamin D status of females in an elite gymnastics program. Clin J Sport Med 2008;18: 159–61. [CrossRef] [PubMed]
20. Mastaloudis A, Traber MG. Vitamin E. In: Driskell JA, Wolinsky I, editors. Chapter 13: Sports Nutrition: Vitamins and Trace Elements. Boca Raton (FL):CRC Press; 2006.
21. Tiidus P, Houston M. Vitamin E status and response to exercise training. Sports Medicine 1995; 20:12-23. [CrossRef] [PubMed]
22. Finaud J, Lac G, Filaire E. Oxidative stress: relationship with exercise and training. Sports Med 2006;36:327-58. [CrossRef] [PubMed]
23. Servais S, Letexier D, Favier R, Duchamp C, Desplanches D. Prevention of unloading-induced atrophy by vitamin E supplementation: links between oxidative stress and soleus muscle proteolysis? Free Radic Biol Med 2007;42(5):627-35. [CrossRef] [PubMed]
24. Rokitzki L, Logemann E, Huber G, Keck E, Keul J. alpha-tocopherol supplementation in racing cyclists during extreme endurance training. Int J Sport Nutr 1994;4:253-64. [PubMed]
25. Evans W. Vitamin E, vitamin C, and exercise. Am J Clin Nutr 2000;72:647S-52S. [PubMed]
26. Ji L. Exercise-induced modulation of antioxidant defense. Ann New York Acad Sci 2002;959:82-92. [CrossRef] [PubMed]
27. Gentili A, Adler RA. Vitamin E Toxicity: Patho physiology. Medscape: Drugs, Disease & Procedures [Internet]. New York (NY): WebMD LCC; [updated Dec 2011; cited Jan 2012]. Available from: http://emedicine.medscape.com/article/126268-over view#a0104
28. Liede KE, Haukka JK, Saxén LM, Heinonen OP. Increased tendency towards gingival bleeding caused by joint effect of alpha-tocopherol supplementation and acetylsalicylic acid. Ann Med Dec 1998;30(6): 542-6. [PubMed]
29. Miller ER 3rd, Pastor-Barriuso R, Dalal D, Riemer sma RA, Appel LJ, Guallar E. Meta-analysis: high-dosage vitamin E supplementation may increase all-cause mortality. Ann Intern Med 2005; 142(1):37-46. [CrossRef] [PubMed]
30. Bjelakovic G, Nikolova D, Gluud LL, Simonetti RG, Gluud C. Mortality in randomized trials of anti oxidant supplements for primary and secondary prevention: systematic review and meta-analysis. JAMA 2007;297(8):842-57. [CrossRef] [PubMed]
31. McCann JC, Ames BN. Vitamin K, an example of triage theory: is micronutrient inadequacy linked to diseases of aging? Am J Clin Nutr 2009;90(4):889-907. [CrossRef] [PubMed]
32. Weber P. Vitamin K and bone health. Nutrition 2001;17(10):880-7. [CrossRef] [PubMed]
33. Boot SL, Tucker KL, Chen H, Hannan MT, Gagnon DR, Cupples LA, et al. Dietary vitamin K intakes are associated with hip fracture but not with bone mineral density in elderly men and women. Am J Clin Nutr 2000; 71:1201-8. [PubMed]
34. Craciun AM, Wolf J, Knapen MH, Brouns F, Vermeer C. Improved bone metabolism in female elite athletes after vitamin K supplementation. Int J Sports Med 1998;19:479-94. [CrossRef] [PubMed]
35. Bucci LR. Nutritional ergogenic aids. In: Wolinsky I, Hickson JF Jr. Nutrition in exercise and sport. Boca Raton (FL): CRC Press inc; 1994.

LIPOSOLUBILNI VITAMINI I SPORT

Novica Bojanić, Jelena Radović, Nina Jančić, Nataša Đinđić

Vitamini predstavljaju ćelijske biokatalizatore, neizostavne faktore u izvođenju osnovnih funkcija organizma. Vitamini rastvorljivi u mastima nisu uključeni u procese vezane za kontrakciju mišića i potrošnju energije, ali mogu indirektno uticati na fizički učinak, jer su važni za funkciju imunološkog sistema (vitamin A, vitamin D, vitamin E), antioksidacionu funkciju (vitamin A, vitamin E) i metabolizam kosti (vitamin D, vitamin K). Trenutno ne postoje jasne preporuke za povećani unos liposolubilnih vitamina kod sportista, kao ni dokaza da sportski učinak može biti poboljšan suplementacijom liposolubilnim vitaminima. U malom broju studija pokazano je da antioksidacioni efekat beta karotena i vitamina E može prevenirati oštećenje mišića i ubrzati oporavak nakon vežbanja. Takođe, sportiste koji izvode vežbe u zatvorenim halama trebalo bi informisati o neophodnosti izlaganja suncu, zbog sinteze vitamina D u koži.

Većina sportista nije dobro upoznata sa svojim potrebama za vitaminima i oligoelementima i uzima ove sastojke u vidu suplemenata bez konsultacije nutricioniste. Važno je naglasiti da se liposolubilni vitamini deponuju u telu i mogu izazvati hipervitaminozu i toksične efekte ukoliko se uzimaju u velikim količinama.

Neosporno je da nedostatak bilo kog liposolubilnog vitamina predstavlja problem za normalne fiziološke procese, međutim, suplementacija nije potrebna sportistima koji imaju dobro izbalansiranu ishranu. *Acta Medica Medianae 2013;52(4):63-68.*

Ključne reči: *liposolubilni vitamini, sport, vitaminski suplementi, hipervitaminoza*

